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For the assessment of patentability the following printed publications have been considered:

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DE	39 05 303 C2
DE	196 41 439 A1
DE	40 04 560 A1
DE	38 73 193 T2
FR	25 47 693 A1
US	53 02 237
US	50 63 329
US	46 11 108
EP	07 10 054 A1
WO	97 45 856 A1

The following information has been derived from the documents submitted by the applicant.

Title: Process And Device For The Treatment Of
                                          Optical And Other Surfaces By Means Of
                                          High Rate Plasma Processes.

The high rate precision treatment process for optical and other materials, according to this invention, uses as a tool, which, on the basis of removal or deposition of substrate material caused by plasma-chemical reactions, a plasma beam source, is fed by a highly reactive form-stable, rotationally symmetrical, localized, gas discharge plasma beam, that is spatially mostly separated from the generating system, and generated by a microwave field at the end of a microwave wave guide, in which arrangement the inner conductor of the coaxial cable is designed in such a way that, in its interior, two or more reactive and / or inert working gases can be separately routed to the open end of the inner conductor, which functions as a nozzle. The effective cross-section between the substrate surface and the gas discharge plasma, which is generated through interaction between the exiting gases and the microwave field, is normally smaller than the dimensions of the substrate surface, and its shaping, by way of removal or deposition, is accomplished in that the substrate and the tool are moved, in relation to each other, with changing or constant speed, in a linear and / or rotating mode. Due to the axial dimensions of the plasma beam of between one and several ten millimeters, the distance between gas exit and substrate surface in this process can be selected to be big enough for even the treatment of strongly curved or structured surfaces ....

[Figure]

[Legend of figure:]

1	Treatment chamber
2	Microwave generator
3	3a/3b coaxial conductors with inner conductor 3b
4	Sliding bridge
5	Gas inlet
6	Substrate holder
7	System that can be moved in a linear (x direction and y direction) and rotational direction
8	Plasma beam
9	Gas outlet

[Subtext figure:]

Schematic drawing of an arrangement for high rate treatment by means of the plasma beam process, with the plasma source being located in the wall of the treatment chamber.

Description

Area of Application

The invention concerns a process and a device for the local treatment of surfaces with high rates of removal and deposition by means of a reactive, microwave-excited plasma beam.

State of the Art

Known treatment processes for the production of precise surface configurations of substrates or layers, in particular in optics, microelectronics or micro system technology, as concerns processes for the removal of material, aside from the abrasive methods of grinding, lapping, polishing, single diamond lathing or milling, are wet chemical etching processes or ion or ion beam etching processes, or combination processes such as chemo-mechanical polishing. As far as coating processes are concerned, they are mainly chemical processes, CVD, physical sputtering deposition methods or laser or plasma coating processes. In this range of technologies, plasma processes have been found to be particularly advantageous because of high process speeds due to high removal and deposition rates, because they are rather easy on the material of the substrate surfaces and coatings that are to be treated (no mechanical contact with the surface during the treatment), and also because of good controllability (sequential local treatment with and without masks).

The advantage of plasma processes as opposed to ion processes lies in the fact that the low kinetic energy of ions in plasma results in less damage being inflicted on layers near the surface; the energy of the ions in the plasma decreases as excitation frequency increases. With dependence on pressure (up to normal pressure), it is also possible to generate plasma with a high density of reactive species, thus allowing high removal or deposition rates to be achieved and technical costs to be substantially reduced in terms of the vacuum technology required.

In this context, the diode arrangement used by Zarowin and Co. to generate plasma with local action (US Patent No.: 4,668,366), in which the surface to be treated either consists directly of an electrode of an RF parallel plate arrangement or is mounted on one, can only be employed if we accept the loss of the above-mentioned advantage of low ion energy. Another clear disadvantage emerges in cases where extremely thick dielectric substrates and/or dielectric substrates of differing thickness are involved, in terms of the associated extreme/non-homogenous weakness of the electric RF field and thus of the etching action which, in this method, is largely determined by the kinetic energy of the ions. One alternative to this method is offered by the so-called "downstream" arrangement: here, the plasma is generated within an electrode arrangement which is open on one side and independent of the substrate; the pressure of the gases in its wake then causes it to be expelled through the open side to whatever distance is required to

bring it into contact with the substrate surface, whereupon a localized action is achieved (e.g. in the form of rotationally symmetrical surface removal).

Building on this method, the group associated with C. B. Zarowin has released a whole series of publications and patents which describe manipulation of the shape of optical surfaces, in particular through the use of targeted overlapping of local material removal combined with dwell/retention time methods ["Rapid, Nonmechanical, Damage Free Figuring Of Optical Surfaces Using Plasma Assisted Chemical Etching (PACE)"; Parts I-II SPIE vol. 966 Advances in Fabrication and Metrology for Optics and Large Optics (1988); pp. 82-97, Bollinger, et al.; "Predicted Polishing Behaviour of Plasma Assisted Chemical Etching (PACE) from a Unified Model of the Temporal Evolution of Etched Surfaces"; SPIE vol. 966 Advances in Fabrication and Metrology for Optics and Large Optics (1988) pp. 98-107, Gallatin, et al.; "Rapid, Non-Contact Damage Free Shaping of Optical and Other Surfaces with Plasma Assisted Chemical Etching" Proceedings of the 43rd Annual Symposium on Frequency Control (1989); IEEE pp. 623-626, Zarowin, et al.; "Rapid, Noncontact Optical Figuring of Aspheric Surfaces with Plasma-Assisted Chemical Etching", D. L. Bollinger, G. M. Gallatin, J. Samuels, G. Steinberg, C. B. Zarowin, Hughes Danbury Optical Systems, Inc., from SPIE vol. 1333 Advanced Optical Manufacturing and Testing (1990), pp. 2-14.; C. B. Zarowin, "Basis of Macroscopic and Microscopic Surface Shaping and Smoothing by Plasma Assisted Chemical Etching," J. Vac. Sci. Technol. B 12(6), Nov./Dec. 1994, pp. 3356-3362.; as well as the patent documents US 5,290,382, US 5,291,415, US 5,336,355, US 5,375,064, US 5,376,224, US 5,811,021]. The processes described in these documents use RF plasma as a tool, which is generated from an appropriately selected mixture of inert and/or reactive gases in a chamber, which is open on one side. As a consequence of the geometry used in these processes, only a very small portion of the plasma volume is actually located outside this chamber at a distance of between a few one-tenths of a millimeter and a few millimeters. The cross-section of the interaction between the emerging plasma and the substrate surface, which is located at approximately the same distance across from the open side of the plasma chamber, is smaller than its overall dimensions; the surface treatment is effected through appropriate overlapping of the spatially-restricted effective cross-section by moving the plasma chamber and the substrate surface in relation to each other. Special materials must be employed [US 5,364,496] to prevent unwanted interactions between the reactive plasma located in the chamber and the chamber walls, which are simultaneously serving as electrodes. For optical materials and semiconductors (Si, SiO_2), etching rates of 3 μm/min are cited as achievable. Higher rates can be obtained using mixtures with NF_3 added, though this has the disadvantage of making it extremely hard to control the geometry of the removal function at the edges.

It is possible to alter the geometry of the "downstream" arrangement so that the opening in the electrode arrangement functions as a nozzle through which the plasma generated inside the chamber is expelled at high velocity as a result of the gas pressure -- this is referred to as a plasma beam arrangement. The advantage of this layout lies in the fact that the figuring of substrate surfaces can be carried out at correspondingly larger distances due to the axial dimension of the generated plasma beam, which has a length of

between a few millimeters and a few centimeters. In this sense, plasma beam processes are especially suited to local treatment of structured and curved surfaces.

Bárdos et al. report on the local etching action on silicon of a reactive plasma beam produced by an RF-excited cylindrical cathode gas discharge ["Superhigh-rate plasma jet etching of silicon", L. Bárdos, S. Berg, and H.-O. Blom, Appl. Phys. Lett. 55, 1615 (1989)], though they do not provide details on the application of this process for the targeted figuring of surfaces containing Si.

Takino et al. ["Computer numerically controlled plasma chemical vaporization machining with a pipe electrode for optical fabrication", Appl. Optics 37, 5198 (1998)] describe the shaping of optical surfaces using a plasma beam arrangement operated at high pressure (600-1000 mbar), where a gaseous mixture consisting of helium and SF_6 at a ratio of 99 : 1 is routed through an RF-linked pipe with an internal diameter of a few millimeters at an He flow of 5 sl/min, resulting in the formation of a plasma beam as the mixture emerges from the pipe. Significant etching action can be achieved at distances ranging from a few tenths of a millimeter up to approx. 2 millimeters, particularly across from the pipe wall due to the increased sputter action of a plasma boundary layer with raised ion energy which forms in this area. The cited etching rates lie in the 2.5 mm^3/h range.

Disadvantages of Existing Technology

The processes used by Zarowin et al. for the local treatment of substrate surfaces with the aid of reactive plasma reveal the following key disadvantages: (i) the fact that the generated plasma only emerges beyond the edge of the opening in the electrode arrangement by between a few tenths of a millimeter and a few millimeters has the result of making the local action of the plasma highly dependent on the distance at which the substrate is positioned as well as creating an associated high dependency on vibrations of the arrangement (such as those which can occur at high scan speeds of multi-axial movement, for example), all of which, firstly, requires the use of costly and complex control systems to achieve high machining accuracy and, secondly, restricts the overall dynamics of the treatment; (ii) the danger of contaminating the surface being processed with extraneous impurities, the majority of which stem from the interaction between the intensive local plasma and the construction materials of the plasma source (etching attacks of the reactive species can be especially intense with regard to the walls of the plasma source in situations involving intensive cylindrical cathode discharges); (iii) associated with the previous point, significant problems in guaranteeing the removal functionality of the plasma tool which is stable in terms of both time and geometry due to the changed geometry of the plasma source components, and (iv) greater wear (tool erosion) of the precision mechanical motion system due to corrosion resulting from the highly reactive species which reaches these components, or alternatively higher investment in the technology of the apparatus in order to avoid this problem through the use of appropriate mechanical protection devices.

The process described by Takino and Co. in "Computer numerically controlled plasma chemical vaporization machining with a pipe electrode for optical fabrication" comes with the substantial disadvantage of a low volume removal rate which is, in fact, achievable with other, technically simpler procedures (ion beam machining), as well as an extremely unfavorable geometry of the cross-section where material has been removed, namely a "hollow beam", which can cause significant problems in surface precision treatment (mathematical deconvolution, machining of small surface details).

On the other hand, the disadvantage described in point (ii) above (contamination of the surface being processed through intensive cylindrical cathode discharges) can, if employed correctly, actually function as a technologically superior variant method for local treatment through material deposition. A patent from Bárdos and Co. (EP 00,166,349) describes such a process in which the pipe electrodes simultaneously function as sacrificial material for coating.

Task of the Invention

It is the purpose of this invention to develop a high-rate treatment process, and a device related to this process, for the precise plasma beam-supported machining of flat or curved surfaces and smooth or structured surfaces of substrates or layers, e.g. quartz, Si, SiC, GaAs and others; whereby, the disadvantages of the known technical solutions cited above are overcome. This applies in equal measure both to those disadvantages of known solutions which concern short serviceable lives of precision mechanical components of the plasma unit -- such as linear translation and rotation tables and their electronic components in the treatment chamber affected by long-lasting corrosive chemical species which spread throughout the container -- as well as to those disadvantages which concern the destructive effects of radiated microwave energy on electronic components and organic construction materials in the treatment chamber.

Solution Provided by Invention

The solving of this task is accomplished by using a device (plasma beam source), according to the invention, to generate, with the help of a microwave field, a highly reactive plasma beam of defined and scalable geometry and high density, which develops at the end of a coaxial microwave wave guide which is open to one side and which consists of an outer conductor and an inner conductor of appropriate geometry; whereby, the inner conductor of the coaxial conductor is constructed of two or more pipes having a suitable cross-section positioned concentrically to each other. Formation of the reactive plasma beam is effected, according to the invention, by diffusing a gas, which is supplied via an external pipe, into the plasma beam, which is formed through the interaction of an inert flow of gas with the microwave field, in such a way that the plasma beam is simultaneously provided with a temporally and spatially stable shape with an axial span ranging from a few millimeters up to a number of centimeters. This gas either contains the chemically reactive species or alternatively such a substance is generated in the plasma discharge from at least one of its components. An essential element of this solution, according to the invention, is that the highly reactive plasma beam does not

itself have any contact with the system of the microwave conductor or the gas supply system integrated within this. This is closely linked to the most advantageous aspect of this solution, according to the invention, in comparison to currently known technology, in that the plasma does not enter into any kind of wall interaction other than with the substrate itself and, as a consequence, (1.) contamination of the plasma and thus the substrate surface with chemical impurities does not occur and (2.) transfer of heat from the plasma beam to the components of the plasma beam source is avoided, making it unnecessary to employ technically complex methods for cooling the surroundings of the plasma beam outlet at the plasma source.

The application focuses on the efficient generation of surface geometries, primarily of a precise, aspherical nature, which deviate substantially from the original geometry of the surface, through the reactive etch removal of material. From an economic point of view, treatment times in this process are kept short thanks to several factors: the achievement of high etching removal rates, the long-term stability of the plasma beam and the fact that it can be controlled so precisely, as well as the fact that a minimum of maintenance is required and that the etching apparatus is easy to operate. The effective cross-section of the generated reactive plasma beam with the substrate surface is smaller than the dimensions of the substrate. However, it may also be equivalent to the dimensions of the work piece, if smaller work pieces are used with additional structured shapes of the microwave wave guiding element, according to the invention, and in accordance with the known technical principles of surface wave guides (SURFATRON principle, see for example M. Moisan, J. Margot and Z. Zahrzewski "Surface Wave Plasma Sources" in O. A. Popov (Ed.) "High Density Plasma Sources", Noyes Publications, Park Ridge, N. J., USA, 1995, in particular pages 217-246).

The shaping of the substrate through material removal is performed, according to the invention, as follows: the substrate, which is contained in a substrate holder preferably equipped with a substrate heating element, and the tool (plasma beam) are moved in relation to each other in a linear and/or rotating fashion at a speed which may be either constant or variable. This is performed in a vacuum container at a pressure ranging from 10 mbar to 1000 mbar; whereby, the relative motion between the substrate and the plasma beam source, which is, according to the invention, located in a pressure capsule in the same vacuum container, is affected through a computer-controlled movement system.

In certain circumstances it is expedient for this substrate shaping process to be effected by removing material through etching at higher substrate temperatures.

Although this technical solution -- particularly in the detail in which it is described in the example embodiment -- is based on a high-rate etching procedure, the solution as per the invention can also be applied, with the same technical and economic benefits, to the process of depositing material for shaping a surface by employing suitable gases containing the elemental or molecular species to be deposited.

In addition to the technical solution given in the example embodiment, which involves local surface treatment achieved through a dwell time controlled relative motion between

the substrate and the plasma beam source, the process, according to the invention, can also be applied using mask technology or flash technology (e.g. variable masks made from aluminum oxide ceramics provided with geometric hole structures) with the aim, for example, of working deep geometrical structures or structural arrays into the substrate materials at high processing speeds and with great accuracy. Once again, the process, according to the invention, can be applied in this case either as a high-rate removal method or as a high-rate deposition method. For tasks involving particularly complex shapes or the treatment of large surfaces, it is also possible to apply combinations of the process, according to the invention, e.g. the process involving relative motion of the plasma source/substrate together with the simultaneous use of a variable structured mask, whereupon additional advantages over currently known technology emerge in terms of both technical factors and process economics.

The task of protecting sensitive and expensive mechanical motion systems in the treatment chamber from corrosion is solved, according to the invention, by subjecting the whole apparatus to an inerting/protective background gas pressure during operation. This pressure is created, according to the invention, by admitting a suitable gas, which has the necessary protective effect on wires and openings, directly into the casings of the precision mechanical, electronic and even optical and optoelectronic components, from where it is then released through the existing openings in the treatment chamber. This guarantees effective cleansing of the components requiring protection with unburnt gas whilst effectively excluding the possibility of contact being made with corrosive constituents. The protective gas (oxygen from a liquid gas tank is used in the example embodiment presented here) is removed via the pump system along with the other gas constituents in the treatment chamber. The destructive, damaging influence of radiated microwave energy on electronic components and synthetic parts in the treatment chamber is suppressed or avoided, according to the invention, by installing an absorber of sufficient dimensions to deal with vagrant microwave radiation in the treatment chamber. In the example embodiment described here, this absorbing function is performed by a plastic tube with water flowing through it arranged in several coils at a few centimeters distance from the wall of the treatment chamber.

Advantages of the Invention

The advantages provided by this invention consist of the following: a reactive plasma beam of high density and scalable dimensions (within certain limits) is generated in such a way that parasitic and thus generally disadvantageous, corrosive, plasma-wall interactions are avoided; with the help of this beam, flat, structured and even curved surfaces of conductive and non-conductive substrates with lateral dimensions widely ranging from millimeters up to meters can be precisely machined by the overlapping of the local effective cross-section with half-width values ranging from approx. 1 mm to some 10 mm at high removal rates of up to 20 mm^3/min, or alternatively coating rates, in such a way that unwanted contamination of the work piece surface through construction materials is avoided and that the distance between the substrate and the gas emerging from the plasma beam source during the machining process does not represent a critical influence, since, in contrast to known solutions, the effective cross-section in this

example is not subject to any critical dependency on this distance. Further advantages of the invention include non-costly measures, comparable to solutions described, for protecting expensive components of the apparatus in the treatment chamber from corrosive gas species and unwanted microwave radiation.

Section B: Description of Example Embodiments

Example 1

This section describes, by means of an example, the manufacture of an optical asphere using the reactive plasma beam etching process. **Diag. 1** shows a schematic view of the arrangement used in this case, consisting of treatment chamber **(1)** suitable for vacuum application and made from corrosion-proof special steel, containing heatable work piece seat **(6, 7)** which can be moved in both a linear (x and y directions) and rotating manner via a computer-controlled system, a microwave system (automatically tunable via sliding bridge **(4)**) consisting of coaxial conductor **(3a, 3b)** whose open end **(9)** is also located within the vacuum chamber, as well as microwave generator **(2)** which is connected directly to the coaxial system. Supply **(5)** of the inert or reactive gases employed (Ar/He or SF_6/CF_4) is affected at the end of the coaxial conductor via inner conductor **(3b)**, which is shown in the example as a double-walled tube. Typical process parameters are given in Table 1.

Diag. 2 shows an example of the cross-section profile of the removal function of plasma beam **(8)**. Typical removal rates with quartz or even with silicon carbide are 1-4 µm/s with half-width values of 5-10 mm. Resulting volume removal rates lie in the range of 1-20 mm^3/min.. Depending on the process parameters, the axial dimension of the plasma beam will range from a few millimeters up to a number of centimeters. A typical value is approx. 20 mm. The targeted overlapping of the local removal function for shaping large-surface substrates is effected through the computer-controlled movement of the substrate in relation to the plasma beam to achieve the average local dwell times, which are mathematically simulated on the basis of the local removal function. In this example, movement is performed in the meander pattern sketched in **Diag. 3**. **Diag. 4** shows a surface shape produced using the reactive plasma beam etching method with a machined depth of approx. 30 µm. The workpiece here consisted of a piece of polished quartz with an external diameter of approx. 140 mm and a thickness of approx. 25 mm. Machining time was approx. 2 hours.

Example 2

The complete microwave system used to generate a reactive plasma beam (plasma source) may also be located in the treatment chamber suitable for vacuum application (**Diag. 1, (1)**) when carrying out substrate treatment such as that described in Example 1. This is achieved by installing the individual components in a vacuum-tight, pressure-resistant container, which is filled either with air or with an inert gas in order to avoid high voltage flashovers.

A diagrammatic view of this "capsule" plasma beam source is provided in **Diag. 5**.

Source housing (10) contains microwave generator (2) and coaxial conductor (3a, 3b) which is sealed off from the treatment chamber by vacuum seals (13) and whose open end, which simultaneously functions as gas outlet (9), protrudes into the treatment chamber. Gas intake into the inner conductor of coaxial conductor (3b), depicted in the example as a double-walled pipe, is affected via supply connection (5). The source fill gas -- in this example air under atmospheric pressure -- is admitted through intake (12). The cooling water used to cool microwave generator (2) is supplied and carried away via supply connection (13), depicted as a double pipe system. The electric power supply cable and the signal lines are flange-mounted on inlet ducts (11). Computer-controlled tuning of the microwave system is effected via sliding bridge (4).

Patent Claims

1. Process for high rate treatment of material surfaces using a plasma beam source, wherein a highly reactive plasma beam of defined and scalable geometry and high density generated using a microwave field develops at the end of a coaxial microwave wave guide, which is open to one side and which consists of an outer conductor and an inner conductor of appropriate geometry; whereby, the inner conductor of the coaxial conductor is constructed of two or more pipes having a suitable cross-section positioned concentrically to each other, and wherein formation of the reactive plasma beam is effected by diffusing a gas, supplied via an external pipe, into the plasma beam formed through the interaction of an inert flow of gas with the microwave field, in such a way that the plasma beam is simultaneously provided with a temporally and spatially stable shape, and wherein the chemically reactive species is either contained in this gas or generated in the plasma discharge from at least one of its components, and wherein the highly reactive plasma beam does not itself have any contact with the system of the microwave conductor or the gas supply system integrated within this, thus guaranteeing that the plasma does not enter into any kind of surface interaction other than with the substrate itself so that, as a consequence, it is free from extraneous impurities.

2. Process of Claim 1, wherein at least one of the process gas components is CF_4, SF_6, NF_3 or XeF_2 and where the plasma beam has contact with the surface of the substrate causing material to be removed through etching. In this process, the cross-section of the plasma beam is smaller than the cross-section of the substrate.

3. Process of Claims 1 and 2, wherein the carrier gas of the plasma discharge excited by microwaves consists of Ar or He.

4. Process of Claims 1, 2 and 3, wherein O_2 is an additional component in the process gas.

5. Process of Claims 1, 2, 3 and 4, wherein the process is performed at a process pressure of between 10 mbar and 1000 mbar in a container, specifically a treatment chamber.

6. Plasma beam source of Claim 1, wherein this source is installed in a capsule container, which is compression-proof and vacuum-tight in relation to its surroundings, in such a way that the open part of the coaxial microwave guide system and the gas flow system integrated in the inner conductor protrude into the treatment chamber.

7. Process of Claims 1, 2, 3, 4, 5 and 6, wherein the plasma beam source is located together with the substrates in the treatment chamber.

8. Process of Claims 1, 2, 3, 4 and 5, wherein the plasma beam source is built into the wall of the treatment chamber in such a way that the source is located outside the treatment chamber whilst the open part of the coaxial microwave guide system and the gas flow system integrated in the inner conductor protrude into the treatment chamber.

9. Process of Claims 1, 2, 3, 4, 5, 6, 7 and 8, wherein, for the purpose of surface treatment through etched material removal, the substrate is located in a substrate holder and is moved in a linear fashion in relation to the plasma beam by means of a multi-axle motion system.

10. Process of Claims 1, 2, 3, 4, 5, 6, 7 and 8, wherein, for the purpose of enabling treatment to be performed using this etching removal method, the substrate is located in a substrate holder and is moved in a linear and rotating fashion in relation to the plasma beam by means of a multi-axle motion system.

11. Process of Claims 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10, wherein, in addition, the plasma source is moved in relation to the substrate by turning and/or tilting and/or changes in distance between the two.

12. Process of Claims 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11, wherein the substrate holder is heatable and the substrate is heated to temperatures higher than room temperature.

13. Process of Claims 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11, wherein the substrate holder is not heatable.

14. Plasma source of Claims 1, 6 and 7, wherein a non-contact temperature measuring system is integrated in the arrangement to measure substrate temperature.

15. Plasma source of Claims 1, 6, 7 and 14, wherein an optical emission spectrometer is integrated in the arrangement.

16. Plasma source of Claims 1, 6, 7, 14 and 15, wherein the end of the inner conductor and the end of the outer conductor are positioned level with each other.

17. Plasma source of Claims 1, 6, 7, 14, 15 and 16, wherein the end of the inner conductor and the end of the outer conductor are not positioned level with each other.

18. Plasma source of Claims 1, 6, 7, 14, 15, 16 and 17, wherein the inner conductor of the above-mentioned coaxial microwave wave guide is constructed of two or more pipes positioned concentrically to each other, in such a way that a gap remains between each of the pipes through which the gas can flow.

19. Configuration of Claims 1, 6, 7, 14, 15, 16, 17 and 18, wherein two or more gases or gas mixtures flow separately to the end of the above-mentioned coaxial microwave wave guide and emerge from this point.

20. Process of Claims 1 through 19, wherein the plasma beam makes contact with the surface of the substrate, whereupon shaping of the surface is affected through the targeted deposition of material by selecting the appropriate process gas components.

21. Process of Claims 1 through 20, wherein structured variable masks, which may consist of aluminum oxide ceramic, or screens, are positioned between the plasma beam and the substrate, thereby enabling geometric structures to be cut in or deposited at higher machining speeds and with greater accuracy.

22. Process of Claims 1 3 21, wherein, for the purpose of protecting sensitive electronic, optical, optoelectronic and mechanical components of the treatment chamber, this chamber is subjected to an inerting/protective background gas pressure during operation;

whereby, this pressure is produced, according to the invention, in such a way that a gas which has the required protective effect on wires and openings is admitted directly into the casings of the precision mechanical, electronic, optical and optoelectronic components, from where it is then released through existing openings in the treatment chamber. The protective gas, which may consist of oxygen from a liquid gas tank, is removed by the pump system along with the other gas constituents in the treatment chamber.

23. Process of Claims 1 through 22, wherein the destructive, damaging influence of radiated, vagrant microwave energy on electronic components and synthetic parts located in the treatment chamber is suppressed or avoided by installing a microwave radiation absorber of sufficient dimensions, which may consist of a plastic tube with water flowing through it positioned in several coils at a few centimeters distance from the wall of the treatment chamber.

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4 pages of drawings included

[Figure]

[Legend of figure:]

Diagram 1   Schematic sectional view of an arrangement for high rate treatment by means of a plasma beam process with the plasma source positioned in the wall of the treatment chamber.

[Figure]

Removal (μm)
Radius (mm)

[Legend of figure:]

Diagram 2   Typical profile of local material removal function of reactive plasma beam.

[Legend of figure:]

Table 1   Typical Process Parameters

[Figure]

Parameter	Unit	Value
Pressure	mbar	100
Microwave energy	W	80
Gas flow Ar	sl/min	0.3
Gas flow SF_6	sl/min	0.3

[Figure]

[Legend of figure:]

Diagram 3   Schematic sectional view of a possible movement pattern of the workpiece in relation to the tool carried out using a computer-controlled x-y motion system.

[Figure]
Height (μm)

[Legend of figure:]

Diagram 4   Example of a surface shape produced by means of reactive plasma beam etching.

DRAWINGS PAGE 4

[Figure]

[Legend of figure:]

Diagram 5   Placing of the plasma source in a vacuum-tight and compression-proof container.